



Transportation Research Division



Technical Report 05-08

Utilizing Lignosulfonates for Gravel Shoulder Stabilization

*Construction, First, and Second Interim Report
September, 2007*

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Utilizing Lignosulfonates for Gravel Shoulder Stabilization

Introduction

The Maine Department of Transportation is responsible for maintaining 8400 miles of state highway. The costs to maintain, construct, and rehabilitate those highways has increased every year. For example from Fiscal Year 2004-2005 to Fiscal Year 2006-2007 construction costs in Maine have increased 35%. To compound the problem, the amount of state and federal revenue has decreased. A portion of Maine's gasoline tax is collected to help fund the Transportation Departments highway program. With the ever increasing price of gasoline combined with more fuel efficient vehicles, consumers are purchasing less fuel which results in decreased tax revenue for the Department. To offset the revenue shortfall the Department trims the number of projects and linear miles of roadway to maintain. In an effort to maintain at a minimum the same linear mileage of roadway year after year the Department has researched many potential cost-effective construction and maintenance products such as Micro Surfacing, Chip Seals, Plant Mixed Recycled Asphalt Pavement, and Foamed Asphalt. Additional cost savings can be realized by blending a roadways gravel base with stabilizing agents such as cement, emulsion, calcium, or asphalt to increase stability and extend the roadways design life. Many procedures have been implemented and are successful in reducing the cost of constructing and maintaining roadways.

Another possible cost-savings could be realized by reducing the amount of gravel shoulder rehabilitation. Every year Maintenance and Operations rehabilitates eroded gravel shoulders by re-grading and compacting the material. If the Department can add a stabilizing agent to the gravel shoulders and prevent or reduce the amount of erosion it could reduce the cost of shoulder rehabilitation. This report will investigate the use of a gravel binding agent to increase stability and reduce the cost of maintaining gravel shoulders and improve the safety of roadways with gravel shoulders.

Problem Statement

A maintenance issue that has the potential for cost savings is the maintenance of gravel shoulders. Maine has 5600 miles of roadway with gravel shoulders that erode with heavy rains. Every year the gravel shoulders erode to a point where the gravel shoulder elevation is as much as 2 inches below pavement elevation and isolated areas can be washed away to a depth greater than that. This elevation change can make it very difficult to control a vehicle that has wandered into the gravel shoulder. In addition, when a gravel shoulder is even with the pavement it gives support to the pavement edge. When the gravel is below the pavement surface that support is diminished and trucks or vehicles that ride along the pavement edge can ravel and crack the pavement. This occurs mainly on inside curves and over time, the cracking can migrate into the wheel path decreasing the load carrying capacity of the roadway. Based on the

Departments Maintenance Activity Tracking System, which is a work accomplishment database that records labor, equipment, and material costs for all maintenance activities, the Department spends as much as 1.14 million dollars per year to re-grade and compact gravel shoulders.

One way to decrease the cost of maintaining the shoulders and improve safety is to add a binding agent to the gravel prior to re-grading and compaction. This could prevent rain water from eroding the gravel and add stability to the shoulder which could reduce pavement edge ravel and cracking and increase the life expectancy of the roadway.

Location

Project Identification Number (PIN) 11538.00 and 11540.00 were selected for gravel shoulder stabilization. Figure 1 contains a Project Location Map.

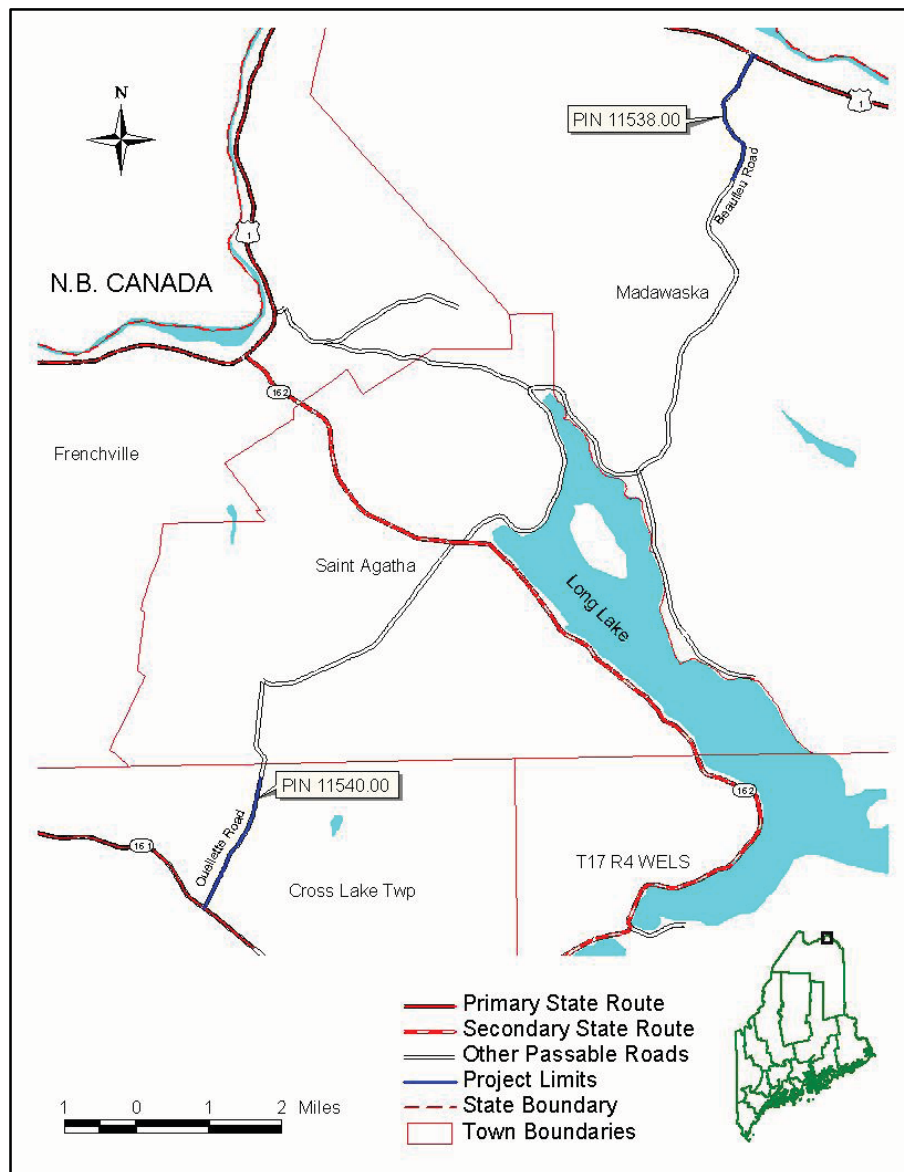


Figure 1 Project Location Map

PIN 11538.00 is located in Aroostook County on the Beaulieu Road in the city of Madawaska. This is a low volume road with a 2005 AADT of 730 with 8 percent Heavy Trucks (AADT). The project is 1.98 miles in length and is scheduled for partial pavement rehabilitation and overlay.

PIN 11540.00 is located in Aroostook County on the Ouellette Road in Cross Lake Township. This is a low volume road with a 2005 AADT of 410 with 8 percent Heavy Trucks (AADT). The project is 2.0 miles in length and is scheduled for pavement rehabilitation.

Materials

The stabilizing agent is called Tembec Dust Suppressant (TDS) and is supplied by BP Trading Ltd. TDS is a lignosulfonate which is a by-product of the paper making process. Lignosulfonate is primarily made of lignon which is the natural polymer that binds tree fibers together. Chemicals used during the pulping process break down lignon into smaller segments which are combined with sulfonic acid to create lignosulfonate. The resulting by-product is non-toxic and non-hazardous to the environment. The binding properties of lignon are retained in the by-product and can be used as a binder for animal feed, fertilizer, carbon black, and soils. TDS is a concentrated product that has to be diluted with water prior to distribution. The mixed product is 50 percent TDS, 50 percent water which results in a product with 25 percent solids by weight.

Shoulder gravel came from two different sources. Gravel for PIN 11538.00 came from the Keegan pit and is a finer material than the gravel used on PIN 11540.00. An aggregate test report with sieve analysis is displayed in Figure 2.

Gravel for PIN 11540.00 originated from the Theriault pit. This is a coarser material with 3.5 percent passing the # 200 sieve. Figure 3 contains a sieve analysis of the material.

Construction

Shoulder stabilization for PIN 11538.00 on the Beaulieu Road in Madawaska began the week of September 5, 2005. Prior to shoulder stabilization the pavement had been removed and the roadway was paved with 1.75 inches of Hot Mix Asphalt Base. The shoulders were graded and compacted even with the asphalt base. The contractor wanted to stabilize the shoulder working off the base course rather than the surface course to reduce scaring of the asphalt surface.

Maine Potato Growers Incorporated was contracted to dispense TDS. The process began with scarifying the north bound gravel shoulder to a depth of 6 inches with a grader, as shown in Photo 1. TDS is then applied over the scarified shoulder at a manufacturers suggested rate of 0.35 gal/yd², see Photo 2. Additional gravel is placed over the treated gravel and the material is brought to grade as displayed in Photo 3. A second coat of TDS is applied at a rate of 0.35 gal/yd², as displayed in Photo 4, and the treated gravel shoulder is then compacted with a Caterpillar CP-323 vibratory compactor, Photo 5. A third coat of TDS is applied at a manufacturers suggested rate of 0.1 gal/yd² to seal the compacted shoulder. Photo 6 displays the compacted shoulder after the final coat.

While scarifying the north bound shoulder it was apparent that there were a number of large pieces of compacted gravel left behind. This can be seen in Photos 1 and 2. To get good stability it's necessary to coat the gravel completely, in particular fine grain material that passes the 200 sieve. In order to get proper TDS penetration, the grader made a second pass with the blade to break up the large gravel pieces. This procedure worked quite well and was used to scarify the remaining shoulders. It took three days to complete stabilization of the shoulders.



CONSTRUCTION AGGREGATES TEST REPORT

Presque Isle Regional Laboratory

SAMPLE INFORMATION

Reference No. 101590	Retest of Ref. No. 	I.A. Comp. No. 	Sample Description SHOULDER ADD AGGREGATE (> 100MM)
Sample Type: ACCEPTANCE	Sampler: ROSS, DANIEL E	Sampled: 9/6/2005	
Sample Location: ROADWAY	Station: 	Offset, ft: 	Received: 9/7/2005
Pit: KEEGAN	Location: KEEGAN	Dbfg, in: 	
PIN: 011538.00	Town: Madawaska	Division: 5	
Contractor: LANE CONSTRUCTION CORP. (THE)	Resident: ROSS, D.		
Maint. Appropriation: 	Region: 	Bridge No. or Town: 	Maint. Contact:

TEST RESULTS

Sieve Analysis (T 27, T 11)

SIEVE SIZE U.S. [SI]	% Passing	Specification
6 in. [150 mm]		100%
4 in. [100 mm]		
3 in. [75 mm]		
2½ in. [63 mm]		
2 in. [50 mm]		
1½ in. [37.5 mm]		
1 in. [25.0 mm]	96	
¾ in. [19.0 mm]	90	
½ in. [12.5 mm]	77	
¾ in. [9.5 mm]		
¼ in. [6.3 mm]	65	25 to 70%
No. 4 [4.75 mm]	59	
No. 8 [2.36 mm]	45	
No. 10 [2.00 mm]	41	
No. 16 [1.18 mm]	31	
No. 20 [0.850 mm]	25	
No. 30 [0.600 mm]	20	
No. 40 [0.425 mm]	16	5 to 30%
No. 50 [0.300 mm]	13	
No. 60 [0.250 mm]		
No. 100 [0.150 mm]	10	
No. 200 [0.075 mm]	8.0	2 to 10%
Wash Method	Procedure A	
Meets?	YES	

Aggregate Quality Tests	Test Result	Specification	Meets?
Los Angeles Wear (T 96), %			
Washington Degradation (MeDOT)			
Fractured, 2 Face (ASTM D 5821), %			
Fractured, 1 Face (ASTM D 5821), %			
Micro-Deval (TP58 99), %			
Method			
Control Agg., Individual Result, %			
Control Agg., Avg. of 20 Results, %			

Moisture-Density Relationship

Test Procedure	
Method	
Hammer Face Used	
Optimum Moisture, %	
Maximum Density, lb/ft³	

Comments:

Sample Meets All Requirements? **YES**

AUTHORIZATION AND DISTRIBUTION

Reported by: **PILSBURY, TERRY**

Date Reported: **9/7/2005**

Distribution:

Paper Copy: Lab File

Electronic: Resident or Contact; Sampler

Distribution for Proctors:

Paper Copy: Lab File; Resident; Freeport Lab

Electronic: Resident or Contact; Sampler

Fax: Freeport Lab

Figure 2 PIN 11538.00 Aggregate Test Report

After the project was surfaced with HMA the shoulder height was lower than the HMA surface. A layer of gravel was placed and compacted on the shoulder to bring the shoulder to grade with the surface. This topical layer of gravel was not treated with TDS.

Shoulder stabilization for PIN 1540.00 on the Ouellette Road in Cross Lake began the week of October 10, 2005. Unlike Beaulieu Road the roadway was completed before the shoulders were treated with TDS. As a result the contractor worked from the HMA surface mix.



CONSTRUCTION AGGREGATES TEST REPORT

Central Laboratory

SAMPLE INFORMATION

Reference No. 101589	Retest of Ref. No. 	I.A. Comp. No. 	Sample Description AGGREGATE SUBBASE-TYPE D
Sample Type: ACCEPTANCE	Sampler: BITHER, JON	Sampled: 9/6/2005	
Sample Location: STOCKPILE	Station: 	Offset, ft: 	Received: 9/7/2005
Pit: THERIAULT	Location: ST AGATHA		
PIN: 011540.00	Town: Cross Lake Twp		Division: 5
Contractor: LANE CONSTRUCTION CORP. (THE)		Resident: ROSS, D.	
Maint. Appropriation: 	Region: 	Bridge No. or Town: 	Maint. Contact:

TEST RESULTS

Sieve Analysis (T 27, T 11)

SIEVE SIZE U.S. [SI]	% Passing	Specification
6 in. [150 mm]		100%, max.
4 in. [100 mm]		
3 in. [75 mm]	100	
2½ in. [63 mm]		
2 in. [50 mm]		
1½ in. [37.5 mm]		
1 in. [25.0 mm]	92	
¾ in. [19.0 mm]	87	
½ in. [12.5 mm]	77	
¾ in. [9.5 mm]		
¼ in. [6.3 mm]	59	25 to 70%
No. 4 [4.75 mm]	53	
No. 8 [2.36 mm]		
No. 10 [2.00 mm]	39	
No. 16 [1.18 mm]		
No. 20 [0.850 mm]	25	
No. 30 [0.600 mm]		
No. 40 [0.425 mm]	13	0 to 30%
No. 50 [0.300 mm]		
No. 60 [0.250 mm]		
No. 100 [0.150 mm]	5	
No. 200 [0.075 mm]	3.5	0 to 7.0%
Wash Method	Procedure A	
Meets?	YES	

Aggregate Quality Tests	Test Result	Specification	Meets?
Los Angeles Wear (T 96), %			
Washington Degradation (MeDOT)	4	15%, min.	NO
Fractured, 2 Face (ASTM D 5821), %			
Fractured, 1 Face (ASTM D 5821), %			
Micro-Deval (TP58 99), %			
Method			
Control Agg., Individual Result, %			
Control Agg., Avg. of 20 Results, %			

Moisture-Density Relationship

Test Procedure	
Method	
Hammer Face Used	
Optimum Moisture, %	
Maximum Density, lb/ft³	

Comments:

Sample Meets All Requirements? **NO**

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN**

Date Reported: **9/14/2005**

Distribution:

Paper Copy: Lab File

Electronic: Resident or Contact; Sampler

Distribution for Proctors:

Paper Copy: Lab File; Resident; Freeport Lab

Electronic: Resident or Contact; Sampler

Fax: Freeport Lab

Figure 3 PIN 11540.00 Aggregate Test Report

Shoulder stabilization began with spraying the existing shoulders with TDS at a rate of 0.35 gal/yd² then spreading a lift of gravel on the shoulder by use of raised dumps with checked tailgates and running down the road. The gravel layer was then sprayed with a second coat of TDS at a rate of 0.35 gal/yd². The treated shoulder gravel was then shaped to grade, compacted and sealed with a coat of TDS at an application rate of 0.1 gal/yd². Shoulder stabilization was completed in three days.



Photo 1 Scarifying Compacted Shoulder Gravel



Photo 2 TDS Treated Scarified Gravel Shoulder



Photo 3 Second Lift of Gravel Shaped to Grade



Photo 4 TDS Application On Second Lift Of Gravel



Photo 5 Gravel Shoulder Compaction



Photo 6 Completed Shoulder

Project Evaluation

Experimental and control sections were delineated on both projects to evaluate the use of TDS as a gravel shoulder stabilizing agent.

PIN 11538.00 in Madawaska has an experimental section between stations 50+00 and 52+00 left. A control section is located between stations 54+00 and 56+00 left.

The experimental section for PIN 11540.00 in Cross Lake is located between stations 118+50 and 120+00 right. The Control Section is located between stations 121+50 and 123+00 right.

Madawaska PIN 11538.00

First Year Evaluation

The experimental section looks very good with no erosion or vegetation on the shoulders as displayed in Photo 7. The gravel shoulder is even with the pavement surface and the gravel surface is very firm.

The Control Section has no erosion and no vegetation. The gravel is even with the roadway as displayed in Photo 8.



Photo 7 PIN 11538.00 Experimental Section



Photo 8 PIN 11538.00 Control Section

Second Year Evaluation

The Experimental Section is in very good condition. A small amount of vegetation is beginning to grow on the shoulder as displayed in Photo 9. There is an elevation change of 0.5 inches between the shoulder and pavement. It appears that a portion of the untreated shoulder gravel that was placed after the project was surfaced with HMA has eroded away as displayed in Photo 10. The gravel shoulder feels solid under foot.

The Control Section is in very good condition with less vegetation than the Experimental Section as displayed in Photo 11. Shoulder gravel elevation is 1.0 inch below the pavement. This Section is located on an outside curve and it appears that the elevation change is caused by traffic riding on the shoulder as displayed in Photo 12.



Photo 9 Experimental Section Vegetation



Photo 10 Experimental Section Elevation Change



Photo 11 Control Section



Photo 12 Control Section Elevation Change

Cross Lake Township PIN 11540.00

First Year Evaluation

There are many areas within the Experimental Section that have erosion lines. Erosion lines begin 3.5 feet from the edge of pavement and run from that point to the ditch line and are between 2 and 3 inches deep as displayed in Photo 13. Photo 14 displays vegetation growing on the shoulders and there is a 0.5 inch elevation change between shoulder and pavement. It appears that the gravel shoulder is stable from the pavement edge to roughly 3 feet from the edge. The project resident stated that they had moderate rains shortly after the shoulders were treated and the TDS may not have had enough time to cure. Another issue is the amount of fines in the shoulder gravel. This project has 3.5 percent passing the # 200 sieve whereas the Madawaska project has 8.0 percent. The TDS representative stated that he typically likes to work with soils that have 10 percent or greater passing the # 200 sieve.

The Control Section has more erosion and vegetation than the Experimental Section. The erosion pattern is similar but the erosion lines begin roughly 2.5 feet away from the pavement edge as displayed in Photo 15. Vegetation has covered considerably more shoulder area as displayed in Photo 16.



Photo 13 Experimental Section Erosion Lines



Photo 14 Experimental Section Vegetation



Photo 15 Control Section Erosion Lines



Photo 16 Control Section Vegetation

Second Year Evaluation

The Experimental Section has less visible erosion and more vegetation than last year is shown in Photo 17. The MaineDOT Maintenance Division re-graded the shoulders in early 2007. The gravel is 1.0 to 1.5 inches below pavement elevation as shown in Photo 18.

The Control Section is almost completely covered with vegetation as displayed in Photo 19. The amount of erosion is similar to the Experimental Section and the elevation change is between 1.5 and 2.0 inches deep as displayed in Photo 20.

Summary

The Control and Experimental Sections on the Beaulier Road in Madawaska have performed very well after being exposed to the elements for two years. There is no erosion and very little vegetation growing on both Sections. It appears that there is no significant difference between the Experimental and Control Sections. The use of finer gravel material may have something to do with the condition of both Sections.



Photo 17 Experimental Section Vegetation



Photo 18 Experimental Section Elevation Change



Photo 19 Control Section Vegetation



Photo 20 Control Section Elevation Change

It was apparent after the first year that TDS stabilization of the shoulders on the Ouellete Road in Cross Lake Township did not perform as expected. There were many erosion lines and vegetation growing on both the Experimental and Control Sections. Although there was a slight reduction of erosion lines and vegetation on the Experimental Section the Maintenance Department deemed it necessary to re-grade the shoulders. It appears that TDS has reduced the amount of vegetation growing on the shoulders even after re-grading. It's possible that the coarse gravel used on this project may have reduced the bonding capabilities of TDS. Given that the shoulders were re-graded, monitoring of this project will be discontinued.

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